SUMMARY OF RESEARCH CONDUCTED BY DR. NADINE G. BARLOW
NO-COST VISITING SCIENTIST
LUNAR AND PLANETARY INSTITUTE
SEPTEMBER 1992 - JANUARY 1996

The research conducted by Dr. Barlow during the term of her no-cost visiting scientist position at the Lunar and Planetary Institute consists of the following areas:

(1) Degradation of craters within Arabia, Maja Valles, Memnonia, and Mangala Valles, Mars.
(2) Incorporation of topography data into Catalog of Large Martian Impact Craters, compiled by Dr. Barlow in 1987.
(3) Areal variations in depth-diameter ratio for impact craters on Mars and Mercury, providing information on changes in target properties across these worlds.
(4) Continuing studies of lobate ejecta morphologies surrounding martian impact craters.

I. Degradation of Impact Craters on Mars.

This project utilizes photoclinometry to determine the current depths and diameters of impact craters in selected regions of Mars. The current depth values are compared to predicted depths of fresh craters of similar size to determine a percentage change in crater depth due to degradation of the crater (either through erosion and/or deposition. The distribution of craters of similar size and degradation state are mapped out for each region. Analyses have been conducted for regions within Arabia, Maja Valles, Memnonia, and Mangala Valles. Results have been published for Arabia and Maja Valles (Barlow, 1995, *JGR*, 100--see attached reprint) and manuscripts are in preparation for Memnonia and Mangala Valles. General results include the following:

1. Localized regions of high, moderate, and low degradation can be identified over areas as small as 100 km^2, compared with previous studies that describe degradation over areal extents of approximately 10^6 km^2.
2. Degradation zones do not necessarily correlate with geologic unit boundaries.
3. Geologic processes responsible for the degradation zones can be constrained based on photogeomorphic analysis of the regions.
4. Areas of low degradation are generally smaller in extent than areas of moderate to high degradation. Areas of low degradation also occur randomly throughout the regions studied. These observations suggest that areas of low degradation represent recent impact events.

Results specific to Arabia:

1. Eolian activity is proposed to be the dominant process affecting the preservation of craters in the 1 to 5 km diameter range within the Arabia region. Three areas of deposition, referred to as mantling deposits, are identified within the study area and are largely responsible for the areas of high and moderate degradation.
2. Fluvial and impact processes play a secondary role in the degradation of the study region in Arabia.

Results specific to Maja Valles:

1. Fluvial outflow channel activity is the primary degradation process which has operated in the Maja Valles study area.
2. Eolian and impact processes play a secondary role in the degradation of craters within the Maja Valles study area.

Results specific to Memnonia:

1. Craters within the Medusae Fossae Formation (thick deposits of friable material) are deeper than general depth-diameter relationships for craters on Mars predict. The fine-grained, friable nature of the target material is suggested to be the cause of this change in depth-diameter ratios for both simple and complex craters.
2. New depth-diameter ratios specific to craters in the Medusae Fossae Formation were computed. The resulting degradation analysis indicates relatively high amounts of degradation for craters both within the Formation deposits as well as in the terrain surrounding the deposits. This is likely the result of active eolian processes (primarily deposition but also some erosion).

Results specific to Mangala:

1. The western region of the Mangala Valles study area displays three areas with extremely low concentrations of craters in the 1 to 5-km-diameter range. One region is covered with deposits from the Medusae Fossae Formation, thus suggesting that eolian deposition is responsible for the destruction of craters in this region. The second region contains a number of small fluvial channels, suggesting fluvial erosion has occurred here. The third region displays a number of lava flow fronts and dune deposits, indicating that volcanic and eolian processes have operated together to destroy craters in the final area.
2. The eastern region of the Mangala Valles study area displays one area of high degradation located near the highlands-plains boundary. Photogeologic analysis indicates that volcanism and eolian processes have destroyed small craters in this region. Large craters within the study area often have rims dissected by fluvial channels and interiors with flat, relatively featureless floors, suggesting localized fluvial activity modified by later eolian activity.

2. Incorporation of Topography and Stratigraphic Data into Catalog.

This project initially was a joint project between Dr. Barlow and Dr. Julie Cave of the University of London. However, because of health reasons, Dr. Cave has been unable to continue with this project. This project is continuing--currently Dr. Barlow is writing a program to take the topographic and stratigraphic unit information in the Mars Digital Image Model and combine them with each entry in the Catalog of Large Martian Impact Craters. Once all craters listed in the Catalog have been associated with the relevant topography and stratigraphic unit, an analysis of variations in ejecta morphologies with elevation and crater diameter will be conducted.

3. Depth-diameter ratio studies for craters on Mars and Mercury.

During the photoclinometric study of impact craters in the Memnonia region of Mars, the depth-to-diameter ratio of fresh impact craters in the thick deposits of the Medusae Fossae Formation was found to be larger than the depth-diameter ratio of fresh craters elsewhere on Mars. Fresh simple craters within the deposits are 79% deeper than craters of similar size outside the deposits; complex craters are approximately 71% deeper. Target properties are suggested to be the cause of this observed variation of depth-diameter ratios. The Medusae Fossae Formation is composed of thick, fine-grained deposits which are easily eroded by aeolian activity, show low values of thermal inertia, and which display little to no radar backscattering at wavelengths of . A likely explanation of why craters are deeper than expected in this region is that less energy is partitioned into breaking up the surface material and more goes into crater excavation. Studies by other groups find that martian impact craters formed in some stronger material such as lava flows display lower depth-diameter ratios (Hayashi-Smith and Mouginis-Mark, 1990), indicating that depth-diameter ratios can be used to constrain general characteristics of target materials.

The depth-diameter results for the Memnonia Region of Mars are being prepared for publication in the *Journal of Geophysical Research--Planets.*

Crater depth-diameter studies also have been conducted for Mercury. Recent radar observations of Mercury suggest the presence of ice in the permanently shadowed floors of impact craters at high polar latitudes. Dr. Barlow, together with Dr. Faith Vilas (NASA/JSC) and Ms. Ruth Allen (Dickinson College), wondered if this ice might extend below the mercurian surface, creating subsurface polar ice caps. On Mars, craters at high latitudes display lower depth-diameter ratios than craters at low latitudes because of relaxation caused by ice in the near surface region. Dr. Barlow, Dr. Vilas, and Ms. Allen utilized shadow length estimates to determine the depths of 220 fresh impact craters identified on Mariner 10 images within the north polar region, south polar region, and selected areas near the equator. Initial results were presented at the 27th Division for Planetary Science Meeting in Kona, Hawaii. No statistical differences in crater depth/diameter were found for craters in the polar and equatorial quadrangles. We are currently conducting a study to determine if we can identify the latitudinal change in martian crater depth/diameter using Mariner 9 imagery which has comparable resolution to Mariner 10. These results will be discussed at the 27th Lunar and Planetary Science Conference, but initial results indicate that the image resolution is sufficient that we should be able to latitudinal variations in crater depth/diameter if they exist on Mercury. The observed lack of variation in crater depth/diameter across Mercury suggests that subsurface ice caps are not present.

The results of this study are described in a manuscript that is in preparation for submission to *Icarus*.

4. Martian Lobate Ejecta Morphologies.

Dr. Barlow has been continuing her studies of the lobate ejecta morphologies surrounding most fresh martian impact craters. Previous studies (1) detected a correlation between ejecta morphology and diameter-latitude which was linked to the presence and physical state of subsurface volatile reservoirs (Barlow and Bradley, *Icarus*, 87, 1990), and (2) quantified sinuosity variations between the different lobate morphologies (Barlow, *JGR*, 99, 1994). The current extension to this project includes (1) incorporation of craters between 1 and 8 km in diameter, (2) inclusion of elevation information, (3) providing limits on the amounts of subsurface volatiles needed to produce the lobate morphologies, and (4) determining local and/or regional variations in morphologies which will provide constraints on the distribution of subsurface volatile reservoirs and possibly information about temporal variations of these reservoirs.

This project is still in its initial stages and is not yet ready for publication. Some preliminary results were presented by Dr. Barlow at the Evolution of Martian Volatiles Workshop at LPI in mid-February, 1996.